3-1920

Bulletin No. 173 - The Duty of Water in Cache Valley, Utah

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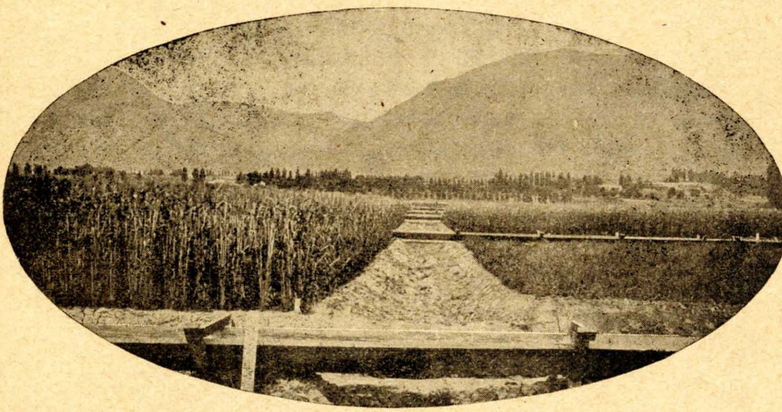

BULLETIN NO. 173

Utah Agricultural College

EXPERIMENT STATION

Logan, Utah

March, 1920

THE DUTY OF WATER IN CACHE VALLEY, UTAH

By

F. S. HARRIS*

The greater part of this bulletin is devoted to a report of experiments on the relation of the amount of irrigation water applied to the yield of crops. As the agriculture of Utah develops, it becomes more obvious each year that the chief factors limiting the production of crops is irrigation water. It is desirable, therefore, to have available all possible information on the subject. Water is so scarce that none should be wasted either directly or by attempting to spread it over so much land that it is not economically applied. Wasteful extravagance on the one hand and undue economy on the other are both bad for the farmer. The best agriculture is realized when as many prosperous farmers as possilbe can be supported by a given area; but it must be remembered that one hundred thoroughly prosperous farmers are better for the community than one hundred and fifty who are unable to make a living.

It is, therefore, very important to the welfare of the state to know just how much land the available irrigation water should be made to serve. It seems clear that irrigation water should be made to go as far as consistent with the prosperity of the individual farmer, but certainly the desire to bring a large area under cultivation should not be allowed to cut the supply of water to the individual farmer below the point at which he can make his farming operation safe and profitable.

The year of abundant water supply should not be used as the standard in determining the area to be served. The average year is also probably not a safe standard by itself; the dry years must also be taken into consideration.

The first step toward either economy or prosperity is to obtain the facts. Guessing is always uncertain. Many of the early explorers on looking at the large rivers of the West stated that the supply of water could never be exhausted. Actual tests, however, have shown that vague estimates of this kind are far from true. No present supply of irrigation water is limitless.

*The irrigation work reported in this bulletin was planned and carried on from 1902 to 1905 under the direction of Dr. J. A. Widtsoe and L. A. Merrill; from 1906 to 1910 under the direction of Prof. J. C. Hogenson; and since 1911 the author has had charge of it. He has been at various times very ably assisted in the field work by A. E. Bowman, H. W. Stucki, H. J. Maughan, and D. W. Pittman. Mr. N. I. Butt gave valuable aid in tabulating results.

The land that can be served from a given water supply has often been overestimated, causing severe material loss to many people. It is exceedingly important to the welfare, not only of the individual farmer but also of the community, that the exact facts be found.

The first stage is to determine the extent of the water supply. The next step is to find how much land can best be served by this supply—not necessarily in extravagance, nor on a starvation basis, but on a basis of adequate prosperity for the largest number of farmers.

WATER SUPPLY OF CACHE VALLEY

The water supply of the western states has been made the subject of careful study on the part of various government and state agencies for a number of years. The hydrographic reports and the water supply papers of the U. S. Geological Survey are full of valuable information on the subject. The reports of the state engineers of the various states have additional information.

As early as 1897 Dr. Samuel Fortier, Irrigation Engineer of the Utah Experiment Station, made a study of the water supply of Cache Valley. This was published as Utah Station Bulletin No. 50. Taken with the reports of the measurements made by the State Engineer and U. S. Geological Survey, it makes accessible rather exact data on the amount of water that is available for irrigation in Cache Valley. The present great need is for more exact information as to the proper area to serve with this water as well as the best methods of applying it.

Since the water supply material may be obtained by any student of the subject it will not be repeated here.

The following figures for the flow of Logan River are given to show how the typical streams of the valley decrease as the season advances. There is much more water available during the early part of the summer than later. This will of course determine the kinds of crops that can be raised.

Table I. Flow of Logan River in Second Feet during June, July, August, and September. Average of 14 Years.

(From U. S. G. S. Water Supply Papers)

	June	July	August	September
Average Mean Flow	1123	566	359	279
Average Minimum Flow	767	399	283	253

Most of the irrigation water of Cache Valley comes from streams flowing out of the east mountains. Logan River is the largest of these and is fairly typical. Some of the smaller streams, however, are entirely dry by the early part of August.

The storage for power purposes of the waters of Bear River which flows through the northwestern part of the valley, is doing much to increase the late water supply of land that is served by this stream. Other means should be sought to increase the late water of the valley so that large acreages of such crops as alfalfa, sugar-beets, and potatoes could take the place of some of the wheat and oats that are raised at present.

CONDITIONS OF THE EXPERIMENTS

The experiments reported in this bulletin were conducted on a deep, uniform loam soil with excellent under-irrigation, two miles north of the Agricultural College at Logan. The soil is typical of that extending around the valley between the shallow bench soil and the heavy soil in the center of the valley. The soil and conditions of the experiments are described in detail in Utah Station Bulletin No. 115. The results can be said to hold strictly only for soils of the same general type as those on which

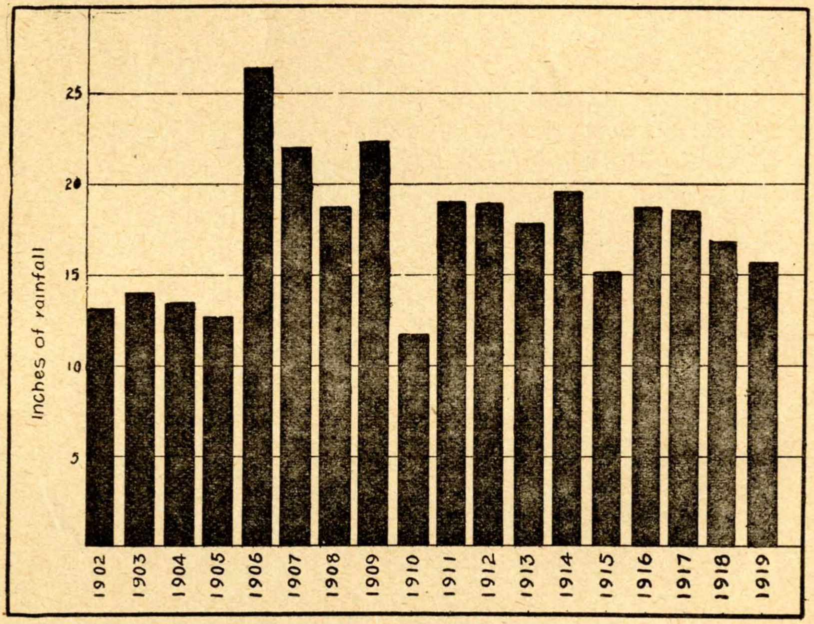

Fig. 1.—Total precipitation at Logan, Utah, during each year **from 1902 to 1920.**

the experiments were conducted, although they should be useful in estimating the water requirements on other types of soils.

The experiments were begun in 1902 and extended up to 1919. This gives a total period of 17 years for certain of the treatments. It is to be regretted that results are not available for all treatments during this entire period.

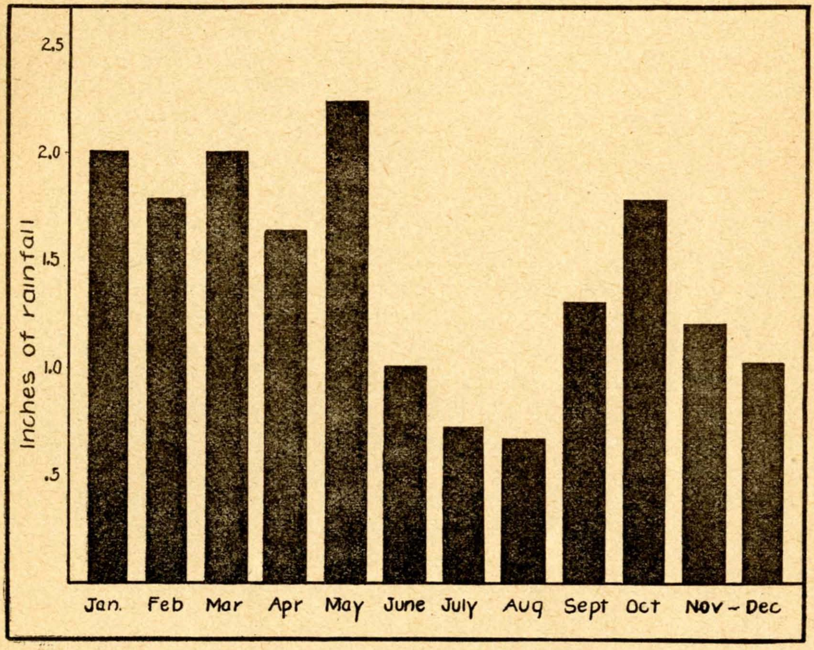

Fig. 2.—Precipitation during each month at Logan, Utah. Average for the years 1902 to 1919.

In order that weather conditions during the period of the experiment might be better understood, the precipitation record is shown graphically in Figures 1 and 2. The first of these shows the total annual precipitation during each year; the second shows the 17-year average precipitation of each month.

The water was measured through a trapezoidal, or Cipolletti, weir and was carried to the land in wood flumes so that the amount given represents the net amount that actually soaked into the soil. In interpreting these results in a practical way, this must be kept in mind since the ordinary farm is subject to ditch and waste-water losses which must be added to the figures given herein.

Irregularities in yields are often traceable to the fact that the complete series were not run through all the years. It must, therefore, be kept in mind that exact yields cannot be given too much weight. It will be much safer to take the results as a whole rather than any one figure or point in the curves. In studying the curves the actual average yields for the different irrigations are shown by the dotted lines, while the heavy line represents a medium yield obtained by considering the average of the greater number of tests to be nearer to the true average than the average of a fewer number and weighting accordingly. A one-year test is not given the same weight in arriving at a point for the heavy curve to pass through as a test covering several years.

RESULTS WITH SUGAR BEETS*

The tests with sugar-beets extended over the entire 17 years of the experiment. Some of the treatments were given during but one year and should not, therefore, be given so much weight as in cases where the experiment was carried on during more years. Table II gives the yield of beets for various quantities of water from 2½ up to 96 acre-inches. The results are shown graphically in Figure 3.

An examination of the table and curve shows that the yield increases with an increased application of water up to about 30

Table II. Yield of Sugar-beets with Various Quantities of Irrigation Water. Total of 200 Trials extending through 17 Years.

Acre-inches Water	Number of Trials	Number of Years	Yield in Tons per Acre
None	8	8	12.18
2½	3	3	13.43
5	35	17	15.58
7½	8	3	15.70
10	37	17	19.41
12½	7	7	20.60
15	38	17	21.05
17½	2	2	21.26
20	16	16	21.96
22½	1	1	18.98
25	3	3	19.53
27½	1	1	24.00
30	10	10	20.38
32½	7	7	20.38
35	1	1	23.51
40	1	1	22.65
45	2	2	23.00
50	9	9	24.54
55	1	1	18.26
65	5	5	15.94
96	5	5	12.95

*For more complete discussion see Utah Station Bulletin No. 156.

inches and that it then declines gradually with the addition of more water. The increase in yield is seen to be more rapid with the smaller applications of water than it is with larger quantities. There is quite a range of water application where the yield is not greatly affected by a little more or less water. This is doubtless due to the difference in the climate during various years. For example, during one year the yield would be highest with 25 inches of water, whereas during a very dry year a higher yield could be obtained with a larger quantity.

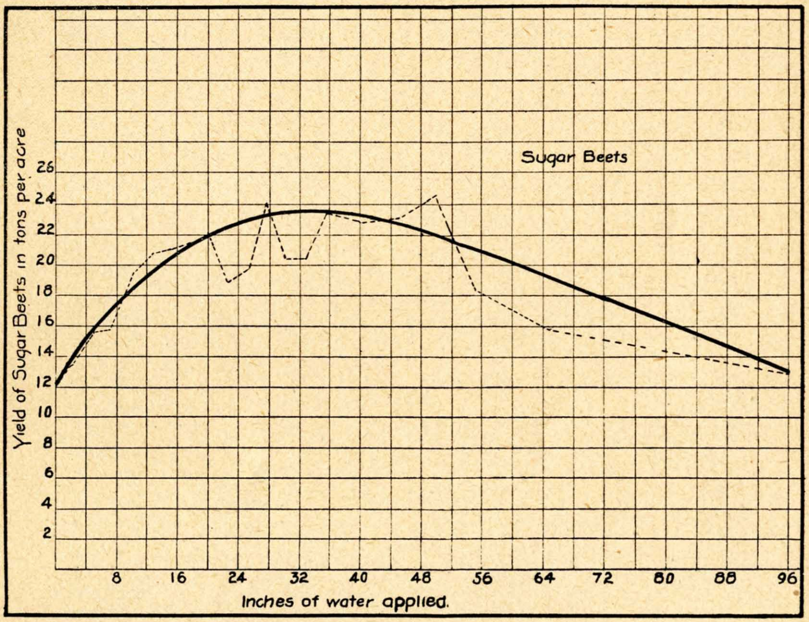

Fig. 3.—Yield of Sugar-beets with various quantities of irrigation water. The diagram represents 17 years' work with a total of 200 tests.

RESULTS WITH POTATOES*

Experiments with potatoes extended over 14 years and included a total of 216 trials. The results are shown in Table III and Figure 4. The highest average yield for any treatment was secured for 32½ inches of water. The 4-year average for this treatment was 377 bushels of tubers to the acre. The average of 12 years' results with no irrigation was 117 bushels per acre.

While considerable variation is noted in the trials during different years, the general tendencies are distinct. The most

*For more complete discussion see Utah Station Bulletin No. 157.

favorable amount of water for potatoes seems to be between 30 and 40 inches. For applications above 60 inches the yield drops very rapidly—much more so than with sugar-beets. This is probably due in part at least to the fact that excessive water prevents the tubers from securing the supply of air that is so necessary to their best growth.

Table III. Yield of Potatoes with Various Quantities of Irrigation Water. Total of 216 Trials extending through 14 Years.

Acre-inches Water	Number of Trials	Number of Years	Yield in Bushels per Acre
None	12	12	117.37
2½	4	4	157.19
5	39	14	162.23
7½	20	9	165.38
10	39	14	217.24
12½	4	4	284.87
15	39	14	228.62
17½	1	1	293.75
20	13	13	266.53
22½	2	2	321.18
25	4	4	204.02
27½	2	2	345.5
30	7	7	269.92
32½	4	4	377.59
40	2	2	341.44
45	8	8	271.39
50	1	1	83.45
55	3	3	240.00
60	6	6	304.00
65	1	1	246.00
67½	1	1	246.00
75	1	1	74.22
82½	2	2	149.00
97½	1	1	85.00

RESULTS WITH ALFALFA

Experiments on the irrigation of alfalfa extended over 14 years with a total of 176 trials. The results are given in Table IV and Figure 5.

An examination of the results for alfalfa shows that this crop can profitably use much larger quantities of water than any of the other crops under investigation. The highest yield was secured with 50 acre-inches. This treatment averaged nearly 5½ tons to the acre during 8 years. There was a decline in yield when quantities of water larger than this were used, but the decline was slow. Alfalfa is seen to be much less sensitive to over-irrigation than potatoes and sugar-beets. Although the

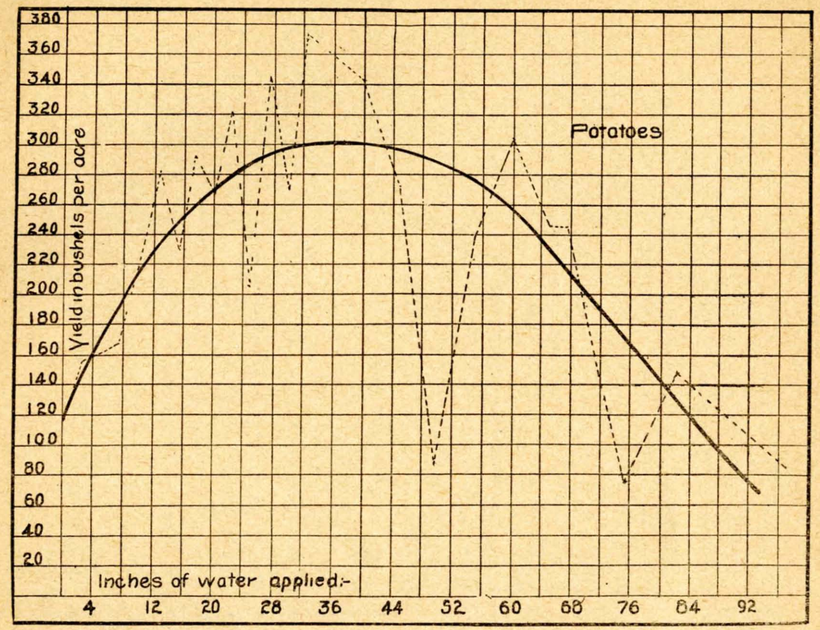

Fig. 4.—Yield of potatoes with various quantities of irrigation water. The diagram represents 14 years' work with a total of 216 tests.

Table IV. Yield of Alfalfa with Various Quantities of Irrigation Water. Total of 176 Trials extending through 14 Years.

Acre-inches Water	Number of Trials	Number of Years	Yield in Tons per Acre
None	14	11	2.655
5	36	7	3.233
10	28	11	3.923
12½	3	3	3.783
15	30	14	4.294
20	12	12	4.165
22½	1	1	4.090
25	14	12	4.544
30	10	10	4.515
32½	2	2	4.841
35	3	3	4.198
37½	1	1	4.400
40	4	4	3.740
45	2	2	4.613
50	8	8	5.355
52½	2	2	3.718
60	1	1	4.691
65	1	1	3.399
67½	1	1	4.230
75	1	1	5.007
90	1	1	4.520
97½	1	1	3.768

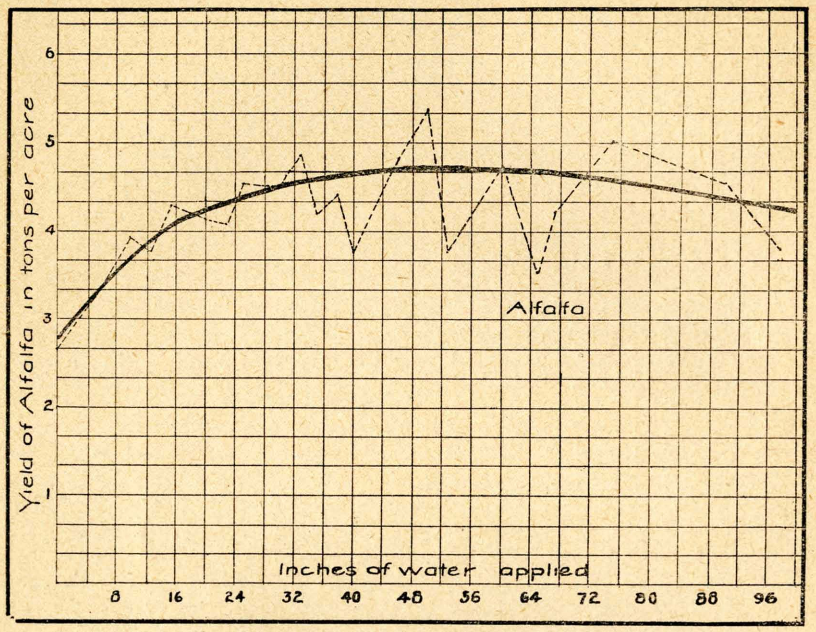

Fig. 5.—Yield of alfalfa with various quantities of irrigation water. The diagram represents 14 years' work with a total of 176 tests.

yield was highest with 50 inches, it was nearly as high with 25 inches.

RESULTS WITH CORN*

Experiments with corn running through 17 years are reported in Table V and Figure 6.

Table V. Yield of Ear Corn with Various Quantities of Irrigation Water. Total of 118 Trials extending through 17 Years.

Acre-inches Water	Number of Trials	Number of Years	Yield in Bushels per Acre
None	13	13	51.33
5	13	13	61.39
7½	8	8	79.14
10	17	17	77.23
15	8	8	93.93
20	17	17	81.80
25	8	8	99.16
30	17	17	81.49
40	9	9	65.30
55	8	8	96.78

*For more complete discussion see Utah Station Bulletins Nos. 133 and 154.

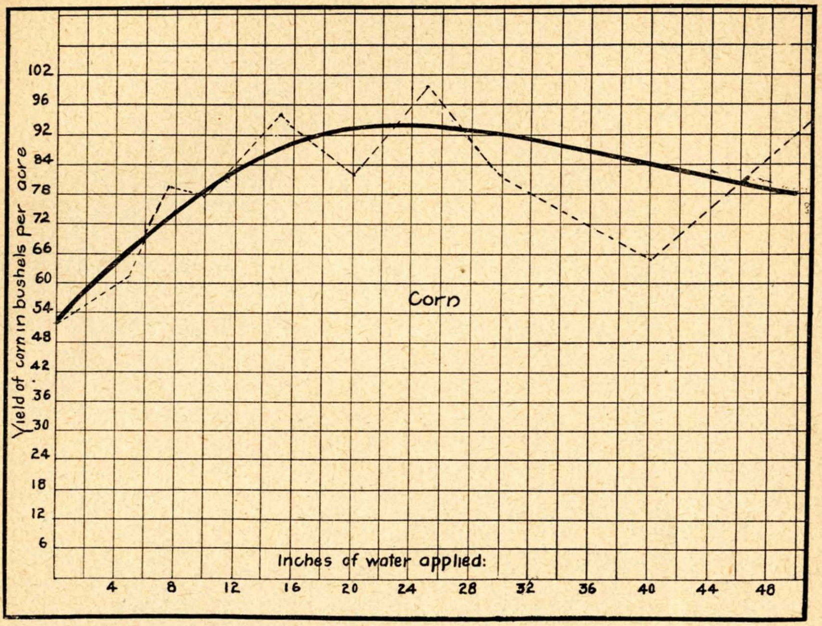

Fig. 6.—Yield of corn with various quantities of irrigation water. The diagram represents 17 years' work with a total of 118 tests.

An examination of the results with corn shows the highest yield with 25 acre-inches of water, although yields are almost the same for all quantities of water between 15 and 30 inches. While the yields were somewhat reduced by excessively large irrigation applications, this was not nearly so much the case as with potatoes and sugar-beets.

RESULTS WITH WHEAT*

In the experiment with wheat as reported in Table VI and Figure 7 it will be seen that the yield was not nearly so much affected by irrigation as was the case with alfalfa, sugar-beets, and potatoes. Fifteen inches of water gave almost as high a yield as any treatment and yet the yield kept up fairly well with the very high irrigations. It will be noted that where no irrigation water was applied the yields of wheat were fairly satisfactory. Therefore, in practice it is doubtful whether more than 15 inches of water would pay for the extra quantity. Were it not for the fact that wheat can use water to advantage early in the season during the period of flood water, it is questionable that

*For more complete discussion see Utah Station Bulletin No. 146.

Table VI. Yield of Wheat with Various Quantities of Irrigation Water. Total of 203 Tests extending through 13 Years.

Acre-inches Water	Number of Trials	Number of Years	Yield per Acre	
			Grain	Straw
			Bushels	Pounds
None	9	9	38.37	3982
5	34	13	38.23	3546
7½	18	9	41.54	3301
10	38	13	42.90	4142
15	34	13	47.16	4796
20	4	4	45.70	5940
22½	4	4	44.60	6757
25	18	9	46.46	4311
35	18	9	48.55	4755
45	4	4	45.80	6250
50	18	9	49.38	5332
67½	4	4	43.50	5794

as much as 15 inches could be used to advantage under conditions similar to those of the experiment.

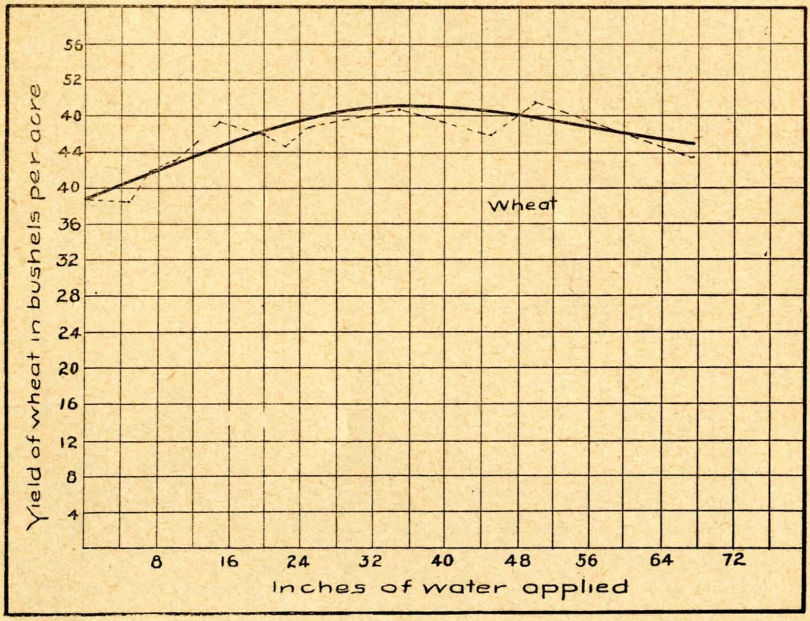

Fig. 7.—Yield of wheat with various quantitiese of irrigation water. The diagram represents 13 years' work with a total of 203 tests.

RESULTS WITH OATS*

The data from experiments with oats are shown in Table VII and Figure 8. The results indicate that the oat plant is more

*For more complete discussion see Utah Station Bulletin No. 167.

sensitive to moisture than wheat. There was a gradual increase in the yield with an increase in water up to 30 inches, above which the yield slightly decreased. The yields were not greatly different for quantities of water between 15 and 45 acre-inches.

Table VII. Yield of Oats with Various Quantities of Irrigation Water. Total of 78 Tests extending through 6 Years.

Acre-inches Water	Number of Trials	Number of Years	Yield per Acre Grain	Yield per Acre Straw
			Bushels	Pounds
None	6	6	50.37	1876
5	21	6	57.51	2077
10	18	6	60.18	2107
15	18	6	72.82	2563
20	6	6	74.40	2723
30	3	3	79.90	2774
45	6	6	76.68	3149

DIVERSITY OF CROPS

It is well recognized by users of irrigation water that all crops do not require the maximum of irrigaation water at the same time. This is fortunate since by having a proper diversity

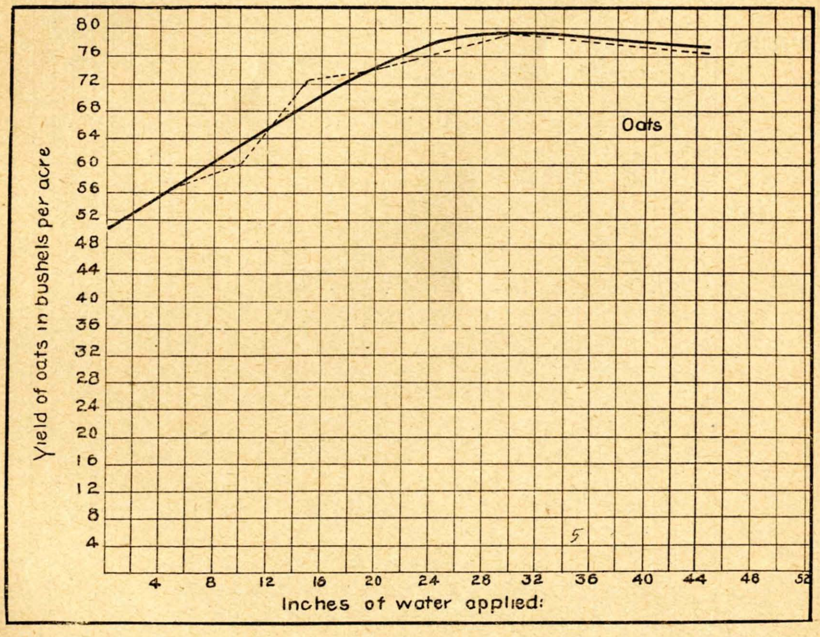

Fig. 8.—Yield of oats with various quantities of irrigation water. The diagram represents 6 years' work with a total of 78 tests.

of crops a much larger area may be served by the same sized stream than if all crops had exactly the same seasonal water requirement. The approximate period during which water is used by the various crops discussed in this bulletin is shown in Figure 9. It is seen that alfafla, wheat, and oats are able to use water early in the season, whereas sugar-beets, potatoes, and corn do not require water till later. Alfalfa, on account of the

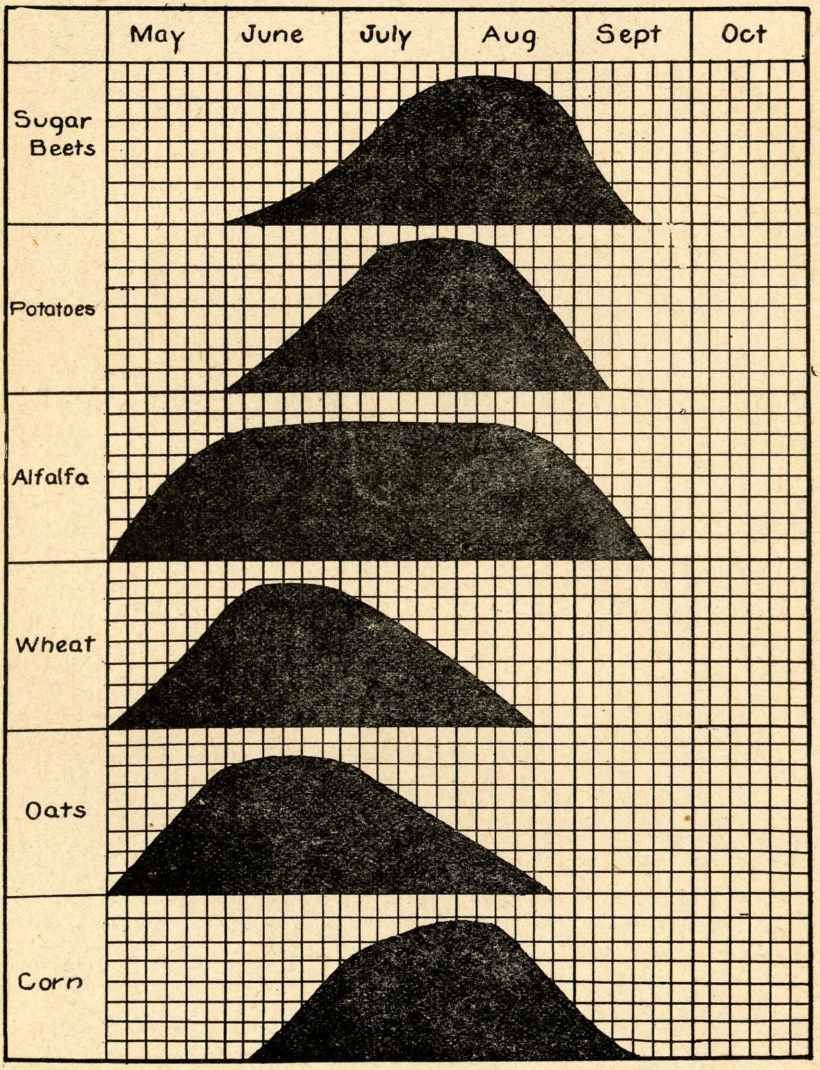

Fig. 9.—Diagram representing the seasonal use of water by various crops in Cache Valley, Utah.

fact that it has no period of maturity but grows throughout the summer season, needs to be irrigated as early and as late as any of the other crops. The small grains mature and cease to require irrigation by the time the demand of sugar-beets, corn, and potatoes is at its highest point.

The crops that are listed could, therefore, be arranged into a rotation that had for its main thought an efficient use of irrigation water.

Of the 181,348 acres in Cache Valley listed by the 1910 census as improved farm land, 77,330 acres were reported as being irrigated. Of this amount about half was producing hay, the greater part of which was alfalfa. Only a few hundred acres of corn were raised. Wheat was the second largest crop. This was followed by sugar-beets, oats, and potatoes in the order named.

The large acreage of alfalfa calls for water throughout the season. The acreage of sugar-beets and potatoes on the one hand as opposed to the small grains on the other will be determined largely by the amount of late water that can be had. Under canals with a poor late water right the relative acreage of wheat and oats will be large. Where the late water right is ample the more profitable crops such as sugar-beets, potatoes, and alfalfa can be raised in larger proportions.

SUMMARY

1. This bulletin reports experiments on the duty of water in irrigating sugar-beets, potatoes, alfalfa, corn, wheat, and oats raised on a deep medium soil in Cache Valley, Utah.

2. The results include a total of 991 tests extending over a period of 17 years.

3. In applying these results it must be kept in mind that the figures refer to water that actually soaked into the land. In practice, ditch and runoff losses should be added to the quantities mentioned here.

4. For sugar-beets from 15 to 30 inches of water gave the best results. The use of more than 30 inches would probably never be justified on this type of soil.

5. The yield of potatoes was increased with increased irrigation up to 32½ inches, but it dropped off rapidly when larger quantities were used.

6. Alfalfa was able to use more water advantageously than any of the other crops. Up to 50 inches increased the yield, but the smaller quantities were much more efficient for each acre-inch of water.

7. From 15 to 25 acre-inches of water gave the best results with corn.

8. The yield of wheat was less affected by water than that of any of the other crops. The best quantity to use would probably be about 15 inches, although there was a slight increase in yield for larger quantities.

9. Oats gave good returns for quantities of water ranging between 15 and 30 acre-inches. Probably the lower quantity would be most profitable unless water were very plentiful.

10. The proper diversification of crops makes possible the most efficient use of irrigation water.

11. The proper amount of irrigation water to use must be based on a great variety of physical and economic factors that vary with each set of conditions. The facts presented in this bulletin are intended to serve as a guide to help each farmer to decide how much water he is justified in using rather than to lay down any definite set of rules to be followed under all conditions.

LIST OF UTAH STATION BULLETINS DEALING WITH IRRIGATION ON DEEP SOILS OF CACHE VALLEY

No.
104. Widtsoe, J. A.—The Storage of Winter Precipitation in Soils.
105. Widtsoe, J. A.—Irrigation Investigations—Factors Influencing Evaporation and Transpiration.
115. Widtsoe, J. A. and McLaughlin, W. W.—Movement of Water in Irrigated Soils.
116. Widtsoe, J. A.—The Production of Dry Matter with Different Quantities of Irrigation Water.
117. Widtsoe, J. A. and Merrill, L. A.—Yields of Crops with Different Quantities of Irrigation Water.
118. Widtsoe, J. A. and Merrill, L. A.—Methods for Increasing the Crop-producing Power of Irrigation Water.
119. Widtsoe, J. A. and Stewart, Robert—The Effect of Irrigation on the Growth and Composition of Plants at Different Periods of Development.
120. Widtsoe, J. A. and Stewart, Robert—The Chemical Composition of Crops as Affected by Different Quantities of Irrigation Waters.
133. Harris, F. S.—Irrigation and Manuring Studies, Pt. I.
146. Harris, F. S.—The Irrigation of Wheat.
154. Harris, F. S. and Pittman, D. W.—Irrigation and Manuring Studies, Pt. II.
156. Harris, F. S.—The Irrigation of Sugar-beets.
157. Harris, F. S.—The Irrigation of Potatoes.
159. Harris, F. S. and Bracken, A. F.—Soil Moisture Studies under Irrigation.
167. Harris, F. S. and Pittman, D. W.—The Irrigation of Oats.

(College Series No. 144)